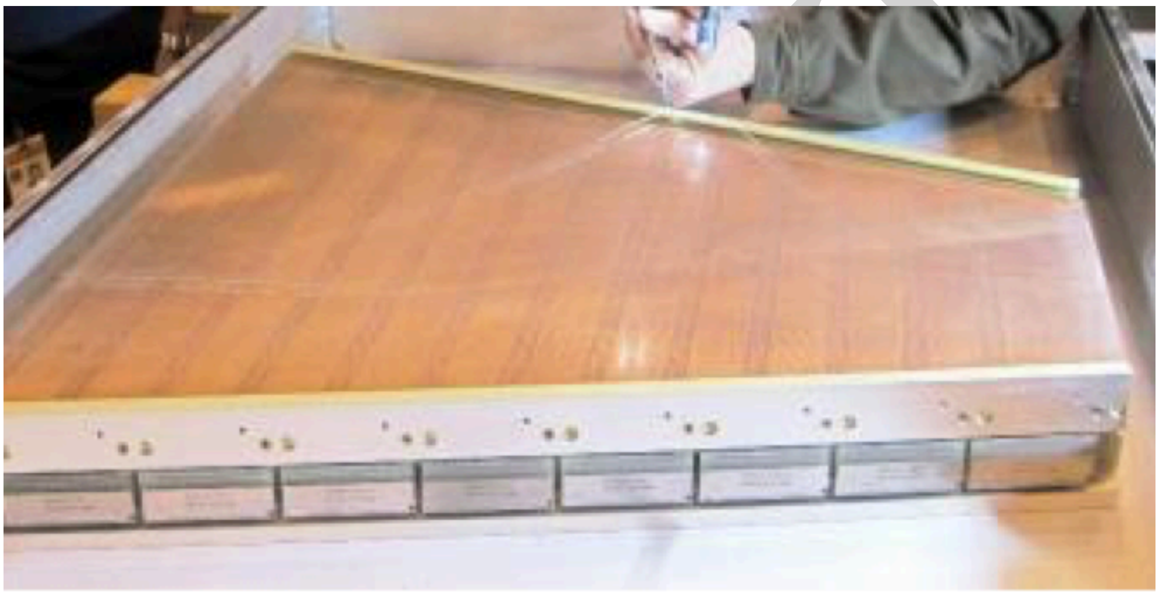
Project Management Plan
for the
STAR iTPC Upgrade



August 12, 2016

Project Management Plan
for the
STAR inner Time Projection Chamber (iTPC) upgrade
at the
Brookhaven National Laboratory

Change Log

Revision No.	Pages Affected	Effective Date
Revision 0	Entire Document	March 2016
Revision 1	Update milestones – update KPP-added Operation Readiness plan in text	June 2016
Revision 2	Updated following feedback from DOE NP	August 2016

1 INTRODUCTION

The iTPC Project Management Plan (PMP) describes the coordination of effort by the project team, including the processes and procedures used by the Project Manager (PM), to ensure that the project is completed on time and within budget. The PMP defines the project scope and the organizational framework, identifies roles and responsibilities of contributors, and presents the work breakdown structure (WBS), cost and schedule.

1.1 Project Background

Brookhaven National Laboratory (BNL), located in Upton, NY, is owned by the U.S. Department of Energy (DOE) and operated by Brookhaven Science Associates (BSA) under the U.S. Department of Energy Contract No. DE-SC0012704. The flagship Nuclear Physics facility at BNL is the Relativistic Heavy Ion Collider (RHIC). Au+Au Collisions will be studied during the Beam Energy Scan phase II (BES II) where the STAR (Solenoidal Tracker at RHIC) will be the only operating detector. The goal of STAR is to obtain a fundamental understanding of the interactions between quarks and gluons, and the iTPC (inner TPC) upgrade will extend STAR's capabilities crucial for BES-II. The BES-II program is an important component and goal of the hot QCD community in the NSAC 2015 Long Range Plan.

The iTPC upgrade was first discussed in STAR 5 years ago as a replacement due to the age of the TPC, and as a way to improve forward measurements. A proposal was written in early 2015 with an emphasis on the highly extended reach of physics program for BES-II. The project was reviewed by the Program Advisory Committee (June 2015), and later got approval to proceed with a Director's Review on January 25, 2016 with participation by the DE Office of Nuclear Physics. The project received permission by DOE NP to proceed in 18 February, 2016.

2 PROJECT BASELINE

This section describes the project Performance Measurement Baseline (PMB), which consists of the scope, cost, schedule, funding profile, and other information related to the PMB.

2.1 Scope Baseline and key physics

The STAR detector was designed to make measurements of hadron production over a large solid angle, and it features detector systems for high precision tracking, momentum analysis and particle identification. It is the only experiment at RHIC that measures particles over the full azimuthal angle and over momenta from 100 MeV/c to 20 GeV/c. Therefore, it is well suited for both characterizing heavy-ion collisions event-by-event and also investigating large transverse momentum effects.

The upgrade to the inner sectors of the STAR TPC will increase the segmentation on the inner pad plane and will renew the inner sector wire chambers. These two improvements will extend the capabilities of the TPC in many ways. Most significantly, the enhanced tracking at small angles relative to the beamline will expand the TPC's acceptance out to pseudo-rapidity $|\eta| \leq 1.5$, compared to the current limitation of $|\eta| \leq 1$. Furthermore, the detector will have better acceptance for tracks with low momentum, as well as better resolution in both momentum and dE/dx for tracks of all momenta. These changes will enable the collection of data that is critical to the physics mission for Phase-II of the Beam Energy Scan (BES-II). The improved dE/dx and momentum resolution, as well as tracking at higher pseudorapidity, will provide the foundation for another proposed upgrade - the endcap time of flight project (endcap-TOF) by the STAR/CBM collaboration.

The Physics program, and the technical description of the project is presented in the iTPC Technical Design Report (TDR), available as STAR Note SN0644[1]. There are two key physics topics that the upgrade will enable (*i*) net-proton kurtosis measurements in a search for a critical point in the QCD phase diagram, and (*ii*) measurements of low mass di-electron pairs to explore the modification of vector mesons in connection with the approach to chiral symmetry restoration in a dense medium.

The enhanced capabilities provided by the iTPC upgrade will allow a full study of observables which are sensitive to changes in correlation length near the critical point. For example, in the vicinity of a critical point, the net-proton kurtosis is expected to rise as the fourth power of the size of the rapidity window but then saturate as the window becomes comparable to, or larger than, the correlation length in the system. The iTPC improvements with increased rapidity coverage will allow the fullest possible coverage of the collision region to establish the existence of a rapid rise in the kurtosis signal and, if found, to more fully map out its properties.

For the low mass di-electron measurements, the iTPC upgrade improves the acceptance of the detector but also reduces the hadron contamination which is responsible for and is the dominant source of systematic uncertainties in previous measurements. The reduction in uncertainty made possible by the iTPC project will allow the full exploitation of the increased statistics to be collected during BES-II. Full characterization of any meson broadening, and distinguishing between competing theoretical interpretations for a quantitative assessment of how the system approaches chiral symmetry restoration, will only be possible with these improvements.

2.2 Technical Performance Parameters

The technical performance parameters and deliverables are given in Table 2-1. Fulfilling these parameters will ensure that the iTC can reach its physics goal in BES-II. The parameters are chosen such that they can be determined before beam operations. It is known from the initial construction and performance of the STAR TPC that if these goals are met then excellent tracking performance will result. See Appendix A for a more detailed description of the technical performance parameters

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[1] https://drupal.star.bnl.gov/STAR/starnotes/public/sn0644

[2] http://rnc.lbl.gov/~jhthomas/public/iTPC/Risk/STARTPC2020riskAnalysis_final.pdf

and how they will be demonstrated. The KPP can all be demonstrated before installation for completion of the project, whereas the UPP requires measurement with beam to demonstrate the required physics performance.

Parameter	Threshold value (KPP)	Ultimate value (UPP)
dE/dx resolution for pions/muons at BES-II energies	-	<6.9% $\|\eta\| \leq 0.1$ < 8.0% $1.0< \|\eta\| \leq 1.2$
Gain at Nominal Voltage	~2000 +-5% at 1150 Volts	-
Tension on Anode Wires	0.50 Newtons ± 0.05	-
Fully working sectors delivered to BNL or repairable at BNL	22	-
HV sections operational	>95%	-
Compatible with STAR DAQ-1000 system	< 8%deadtime @ 1kHz and 30% @ 2 kHz from iTPC inner sectors	< 5% @ 1kHz and 20% @ 2 kHz dead time from iTPC at BES-II energies
Operational electronics fraction	Less than 8% dead channels per sector	Less than 3% dead channels for full system
Electronic Noise	< 2 ADC counts	-
Electronics gain Uniformity	<10%	

Table 2-1: Key Performance parameters for iTPC. See appendix for additional information.

Mechanical	24 fully tested inner sectors plus 2 spares
Electrical	24+3 sets of FEE cards (55 per sector) to readout 3600 pads per sector. RDOs for the 24 sets of FEE cards.
Power Supplies	Power Supplies for 24 inner sectors
DAQ	DAQ PCs to readout 24 fully instrumented inner sectors

Table 2-2: Project deliverables for the iTPC upgrade.

2.3 Cost Baseline

The cost baseline for the DOE TPC is $ 3,600K. Table 2-3 shows the cost summary at WBS Level 2 in At-Year (AY) dollars. Contingency is 21% of the estimated cost of the project.

WBS	Title	Cost ($k)

1.1	Project Management	240
1.2	Padplane	105
1.3	mechanical	1143
1.4	Integration & installation	136
1.5	Electronics	1352
	Contingency	625
Total Estimated Cost (TEC)		3600
Total Project Cost (TPC)		3600

Table 2-3: iTPC Cost Summary

Cost estimates were developed from a bottoms-up analysis of each contribution to the scope of the iTPC project as well as contingency funds needed as an allowance for uncertainties, omissions, and risks. The cost estimates are based on experience with the DAQ1000 project and using preliminary quotes for critical, large cost, items. Since the project has essentially completed the R&D phase, and the mechanical parts are ready for fabrication, the overall project contingency is modest (~20%).

2.4 Schedule Baseline

Fiscal years	2016				2017				2018				2019			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Mechanical																
padplane																
Strongback padplane production																
Padplane Assembly																
Assemble MWPC																
Sector Installation																
Electronics																
RDO																
SAMPA																
FEE																
Electronics installation																
Roll-in and commisioning																
Insertion Tool																

Table 2-4 Schematic Schedule The critical path for the mechanical and electronics schedule are shown in red.

2.4.1 Schedule

The current schedule has STAR ready for data taking on mid-March, 2019 with ~1.5 months of commissioning after installation and before beam. Early testing of individual sectors may be possible by utilizing the benefits of staged delivery of the sectors from Shandong University. A key goal of the project is to have the upgrade complete for Run-19.

The critical path for the project goes through the production of padplanes, assembly, production of MWPC and the installation. The installation schedule is driven by the end of run 18 (May 2018), the minimum time that is estimated to prepare TPC end wheels for extraction and installation of inner sectors, and re-installation of electronics and services for the full TPC. The other long lead time items is the production of the MWPC at Shandong University with the last delivery of tested sector to BNL in October 2018. The electronics schedule has 4 months of float, excluding the final mounting of the SAMPA chips. The installation schedule is kept to the minimum with a conservative estimate for extraction and installation time. The time between RHIC run periods precludes having significant float for that activity.

2.4.2 Milestones

Milestones will be used to mark the progress of scheduled tasks. A milestone may mark the start, an interim step, or the end of one or more activities as needed to provide insight into the project's progress. The following tables detail the high level milestones for the project. In addition, there are several lower level milestones in the project WBS schedule.

Management		
	Project Start	2/18/2016
	FY16 Review	9/30/2016
	FY17 Review	9/30/2017
	FY18 Review	9/30/2018
	Project Closeout	12/1/2019
Mechanical		
	Pad plane PCB finalized	2/22/2016 (A)
	Pre-production pad plane complete	7/1/2016
	Strongback drawings finalized	1/28/2016 (A)
	First Batch Padplane production complete	9/1/2016
	First strongback ready for inspection	6/3/2016 (A)
	Strongback production complete	8/9/2016
	First strongbacks joined and shipped	1/16/2017
	MWPC production assembly starts	2/1/2017
	First 2 sectors at BNL	9/6/2017
	Last 6 sectors at BNL	10/3/2018
	Sector testing complete on floor	10/31/2018
Electronics		
	Receive SAMPA prototype	9/19/2016
	Prototype FEE ready for test in run-17	1/15/2017
	FEE preproduction complete	8/10/2017
	FEE production starts	5/1/2018
	RDO prototype complete	11/11/2016
	RDO preproduction design start	5/1/2017
	RDO final design signoff	3/5/2018
	RDO production complete	8/1/2018
	FEE assembled with SAMPA and ready for installation	10/25/2018
Installation		
	Start work of STAR detector in Assembly Hall after run-17	6/16/2017
	Insertion tooling tested and 1 sector replaced	11/3/2017
	Start sector Installation	5/16/18
	East installation complete	9/19/18
	West Sectors installation complete	12/12/2018
	Electronics complete Installed	1/30/2019
	Full system commissioning Complete	3/27/2019
	Table 2-5 iTPC milestones	

The project are depending on external dates that is being tracked by project. Of particular importance are those for the RHIC run-starts and ends, the progress of the insertion tooling and platform fabrication, and the delivery of the prototype and final SAMPA chips that the project relies on.

	End of Run 17	5/29/2017
	Start of Run 18	2/1/2018
	End of Run 18	4/25/2018
Insertion tooling and platform	Platform detailed design start	8/22/2016
	Platform fabrication start	12/1/2016
	Platform delivery	5/1/2017
	Tooling Box completed at BNL	11/1/2016
	Gear system design complete	10/15/2016
	Insertion Tooling assembled	2/1/2017
SAMPA	Prototype SAMPA sample	9/1/2016
	MWP3 chips for one sector	11/1/2017
	Delivery of chips for production FEE	9/1/2018

Table 2-6 Tracking milestones

2.4.3 Work Breakdown Structure (WBS)

The iTPC project has been organized into a WBS for the purposes of planning, managing and reporting project activities. Work elements are defined to be consistent with discrete increments of project work. Project Management effort is distributed throughout the project.

Table 2-7 summarizes the WBS definitions at Level 2. A more detailed WBS Dictionary is provided in Appendix B of this document, including more detailed descriptions of the tasks associated with each Level 2 WBS item, their deliverables and interfaces.

1.1	Project Management	Level of effort tasks associated with the daily management, oversight, and assessment of the project. Oversight, documentation, and reporting, included.
1.2	Padplane	Fabrication, of pad planes and other PCBs needed for assembly of the strongback
1.3	Mechanics	Deliverables and effort related to the fabrication of the strongback, joining of the pad plane to the strongback, and fabrication and mounting of the MWPC on the strongbacks. Including testing prototypes and the final sectors before installation.
1.4	Installation	The infrastructure modifications necessary to support assembly, testing and installation of the inner sectors. Electronics installation is part of this effort. Overall safety management for the iTPC and coordination with the BNL safety committees is provided.
1.5	Electronics	Development of the FEE, RDOs, including fabrication and testing. Electronics also covers associated power supplies, and cabling.

Table 2-7: The iTPC project described and defined at WBS Level 2.

2.5 Funding Profile

		FY16	FY17	FY18	Contingency	Total
Mgt	1.1	54	92	94	45	285
Padplane	1.2	105	0	0	17	122
Mechanics	1.3	865	264	15	238	1381
Installation	1.4	0.0	0.0	136	31	168
Electronics	1.5	19	277	1056	296	1648
Total DOE		**1,042**	**632**	**1301**	**628**	**3603**

Table 2-8: Planned spending profile for the iTPC in at-year (AY) $k of DOE capital funds at BNL.

2.6 Planned BNL Funding

The iTPC project has been set up as a BNL Capital project with a planned funding profile of $k1,200 in each of the 3 fiscal years FY16, FY17 and FY18.

2.7 Foreign Contributions

Shandong University (SDU) is a strong STAR institution with clear commitment to the iTPC project. A '973' State Key Project from the Chinese Ministry of Science and Technology for RHIC-STAR physics was approved in 2013. It provided 2M RMB (~ $308K, currently), to support the iTPC R&D in Shandong University and SINAP in China. The University also provided support (~ 0.5M RMB) for the start-up of the laboratory facilities. For the full production and assembly of the inner sector MWPCs (24 + spares) in China, SDU submitted a proposal for additional support in March of 2015 together with USTC and SINAP, and was awarded ~3M RMB as an NSFC key project for international cooperation (2016~2020). The award was received in September 2015. There are additional in-kind contributions from Shandong University valued at 1.5M RMB. These funds are not included in the project costs. The production at SDU will take place at a refurbished facility, and the engineer, technicians and physicist labor are contributed to the project. The work at SDU is included in project file, as is milestones for production steps.

2.8 Baseline Change Control

Changes to the approved technical, cost, and schedule baselines will be controlled using the thresholds described in Table 6-1 .

The change request will be initiated by the sub-system manager regarding a change to the cost, schedule, or technical baseline. A draft Project Change Request is generated by PM and pertinent data/documents are attached.

All Level 3 PCRs will be approved by the PM. Level 1 and 2 PCRs will be submitted by the PM to the Physics Department Associated Chair person for Nuclear Physics. All Level 2 PCRs will be reviewed and approved by the Physics Department associate Chair. For PCRs exceeding the thresholds of Level 2, they will forward them to the ALD for Nuclear and High Energy Physics with a recommendation for approval.

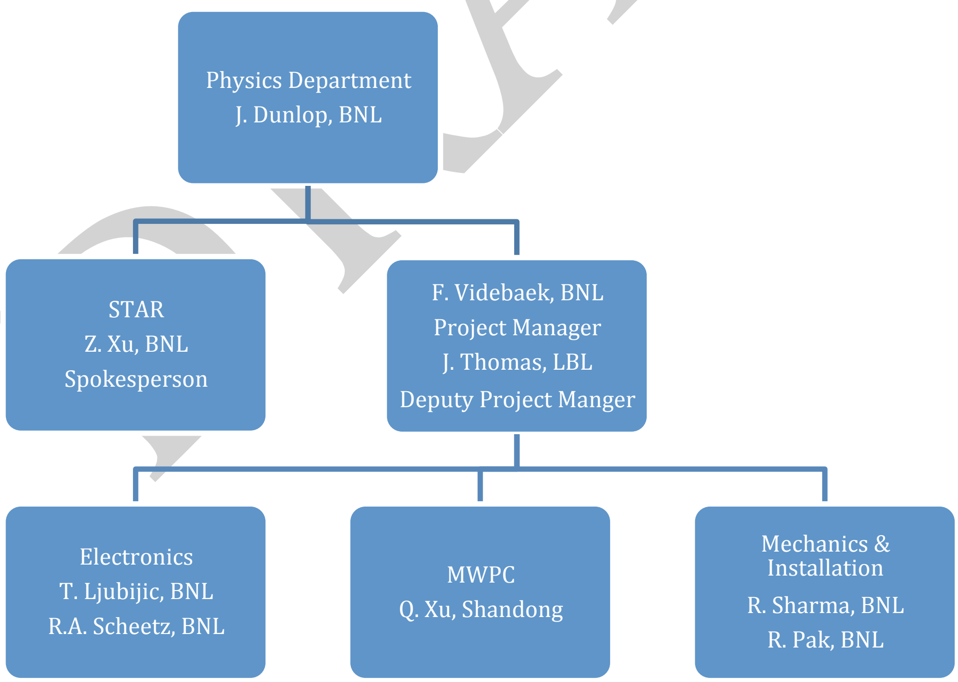
If the change is approved, PM is responsible for implementing the approved cost, budget, schedule or milestone changes in the official iTPC documents. If approval is denied, no changes are made to project documents. All PCRs, approved or rejected, are maintained in the document repository.

	NPP Associate Lab Director (level 1)	BNL-PO Ass. Chair (level 2)	iTPC Project Manager (Level 3)
Technical Baseline	Any change to technical scope that could adversely affect the science scope	Change to any WBS element that does not affect overall technical scope, but could impact initial performance	N/A
Cost	Any increase to the TPC or accumulated allocation of more than $400k contingency	Increase to any WBS element level 2 or allocation of between $200k and $400k contingency.	Increase to any WBS element level 3 or allocation of contingency up to $200k.
Schedule	Any delay of the anticipated completion date	Delay over 3 months of any milestone	Delay over 1 month of any milestone

3 MANAGEMENT STRUCTURE

3.1 Management Structure and Team

This section provides the organization and management chart for the iTPC project.



Project manager: F. Videbaek
Deputy Project manager: J. Thomas

Integration: R. Pak, R.Sharma, B.Soja, A.Lebedev
Electronics Subsystem: T. Ljubicic, R.A.Scheetz
MWPC subsystem and China Liason: Q. Xu, C.Yang, J.Chen
Strongback, and Installation: R.Sharma, B.Soja
Physics: D.Cebra, D.Keane
LBNL Engineering liaison: E. Anderssen

3.2 Management Responsibilities.

Associate Chair for Nuclear Physics in Physics Department , Brookhaven National Laboratory

- *Ultimately responsible and accountable to the DOE for executing the Project within scope, cost and schedule in a safe and responsible manner.*
- *Provides access to laboratory/contractor resources, systems, and capabilities required to execute the Project.*

iTPC Project Manager (PM)

- *Reports to the Associate Department Chair for Nuclear Physics of the BNL Physics Department and has the responsibility and authority for delivering the project scope on schedule and within budget.*
- *Manages the execution of the project to ensure that the project is completed within approved cost, schedule and technical scope.*
- *Ensures that effective project management systems, cost controls and milestone schedules are developed, documented and implemented to assess project performance.*
- *Ensures that project activities are conducted in a safe and environmentally sound manner.*
- *Ensures ES&H responsibilities and requirements are integrated into the project.*
- *Oversees design, fabrication, installation, and construction. Represents the project in interactions with the DOE.*
- *Requests and coordinates internal and external peer reviews of the project. Responsible for risk evaluation and management in accordance with the risk management plan.*
- *Manages the interface and coordination of requirements with other STAR projects.*

iTPC Deputy Project Manager (DPM)

- *Assists the PM in all matters relating to the iTPC Project, including the planning, procurement, disposition and accounting of resources, progress* *reports on project activities, ESSH/QA issues, and Risk Management. In the absence of the CPM, the DPM assumes the project management responsibilities.*

iTPC Subsystem Managers

- *Report directly to the PM*
- *Responsible for the design, fabrication, assembly, and testing of their subsystem in accordance with the performance requirements.*
- *Provide a quarterly status reports on both technical progress and schedule.*
- *Participates in weekly management meetings*

3.3 Participating Institutions

The following is a list of the institutions that participates in the fabrication of the deliverable hardware for the iTPC project. These institutions, and more, will participate in the development of the physics program.

Brookhaven National Laboratory - BNL	Mgt., electronics, installation, testing
Czech Technical University in Prague - CTU	physics
Kent State University - KSU	physics
Lawrence Berkeley National Laboratory - LBNL	Mgt., assembly
Nuclear Physics Institute, Academy of Sciences	NPI
Shandong University, China - SDU	MWPC construction
Shanghai Institute of Applied Physics SINAP	testing
University of California at Davis UCD	physics
University of Science and Technology of China USTC	MWPC construction

Table 3-1: Participating Institutions

BNL has overall responsibly for this Capital Project. Institutional responsibilities for the major activities are: BNL for the electronics fabrication, installation of sectors integration with STAR, and project management. LBNL scientists, with the LBNL Engineering Division, for strong back assembly and project management. Shandong University, Shanghai Institute, and University of Science and Technology of China for MWPC assembly and testing. An agreement on joint research on STAR/TPC upgrade and experimental sudy of BES-II has been written and signed to define the relationship between STAR and Shangdong University, Shanghai Institute of Applied Physics, and University of Science and Technology of China.

4 PROJECT MANAGEMENT AND OVERSIGHT

4.1 Risk Management

Risk management is based on a graded approach in which levels of risk are assessed for project activities and elements. Assessments of technical, cost and schedule risks are conducted throughout the project lifecycle.

The iTPC risk management approach consists of a five-step process:

1. Identifying potential project risk – any member of iTPC team may identify a potential risk. The subproject (WBS level 2) managers are responsible for addressing the potential risks with the DPM or PM's concurrence.

2. Analyzing project risk - the probability of a project risk occurring will be evaluated together with the potential impact to the project's technical performance, cost and/or schedule baseline. Probability is assessed qualitatively (Low, Moderate, and High).

3. Planning for and developing risk abatement strategies.

4. Executing risk abatement strategies - abatement strategies differ according to the potential risk and its timing. Monitoring and tracking the results and revising risk abatement strategies - risk assignments are associated to specific WBS entries down to Level 3. This serves to emphasize the role of the Level 2 WBS manager in risk management. Risk information, including the probability and impact assessments and brief summaries of mitigation strategies, are stored in the iTPC risk registry.

The risk management Plan can be found in Appendix C. The most important risks for the iTPC project and the TPC are documented in the report[2] on "Risk assessment for future TPC operations and the iTPC upgrade" of November 30, 2015 as requested by the ALD for NP.

4.2 Project reporting

The PM will lead quarterly cost and schedule reviews and report the results to the Physics department. The PM and the associated Physics Department chair will participate in quarterly teleconference calls with the DOE Office of Nuclear Physics.

[2] http://rnc.lbl.gov/~jhthomas/public/iTPC/Risk/STARTPC2020riskAnalysis_final.pdf

The standard BNL accounting system is the basis for collecting cost data, and the Control Account structure for the iTPC will separate costs according to the WBS elements. A direct one-to-one relationship will be established between each WBS element of Level 2 or lower with a separate control account in the BNL accounting system.

Technical performance will be monitored throughout the project to ensure conformance to approved functional requirements. Design reviews and performance tests of the completed systems will be used to ensure that the equipment meets the functional requirements.

4.3 Engineering and Technology Readiness

The project will assess engineering and technology readiness through design reviews, IPRs, and other independent technical reviews as required.

4.4 Quality Assurance and Configuration/Document Management

The project shall adopt in its entirety the BNL Quality Assurance Program maintained in the SBMS. This QA Program describes how the various BNL management system processes and functions provide a management approach that conforms to the basic requirements defined in DOE Order 414.1C, Quality Assurance. These requirements will include:

- Management criteria related to organizational structure, responsibilities, planning, scheduling, and cost control
- Training and qualifications of personnel
- Quality improvement
- Documentation and records
- Work processes
- Engineering and design
- Procurement
- Inspection and acceptance testing
- Assessment

The quality program embodies the concept of the "graded approach" i.e., the selection and application of appropriate technical and administrative controls to work activities, equipment and items commensurate with the associated environment, safety and health risks and programmatic impact. The graded approach does not allow internal or external requirements to be ignored or waived, but does allow the degree of controls, verification, and documentation to be varied in meeting requirements based on environment, safety and health risks and programmatic issues.

4.5 Operation Readiness Plan

To ensure that STAR will be ready to operate with the new inner sectors and the associated electronics the constructing and testing plan includes time achieve this goal.

The project plan includes sufficient time to develop prototype for the electronics readout, and checkout of these both with and without beam. The strategy for development and production of the electronics and associated firmware follow the successful model of the implementation of DAQ1000 in 2006-2009. This will first allow for test of one or two FEEs with RDO on an existing inner sector, a full sector instrumented with electronics the next running period, before the final installation of all electronics for subsequent years. This also allows for development of any new online, offline code well ahead of the physics run, though changes resulting from adding the additional rows 13->40 in the inner sectors should be minimal and easy to implement and test.

4.6 ESSH Plans for Fabrication

The iTPC upgrade for STAR will use the BNL SBMS to identify and control hazards for all equipment and work at BNL for the iTPC. The Physics Department and the C-AD have review processes that comply with the BNL SBMS. The project will prepare designs and work procedures and have them reviewed by the appropriate laboratory or department review committees. The equipment and work practices used at STAR will be reviewed by the C-AD Experimental Safety Review Committee (ESRC). The reviews of the ESRC are covered in C-AD Operations Procedures Manual (OPM) Chapter 9 Section 2. The installation will be covered under the rules and safeguards in place for work in the RHIC experimental halls and assembly area.

4.7 Project Closeout

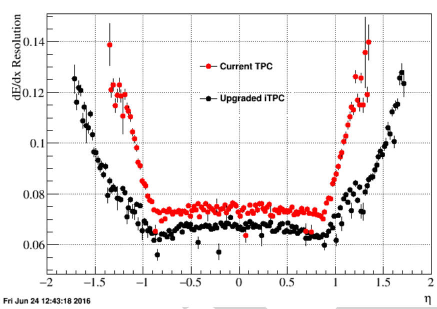
Project closeout will begin when all equipment is ready for installation in the STAR detector. A Closeout Report will be developed prior to the date that closeout is expected in order to demonstrate the fulfillment of the KPPs and deliverables. The report will address the closure status of purchase orders, the expected total cost of the Project and the value of remaining contingency. The report will also explain when the Project is expected to close the control accounts and complete the financial closeout. DOE will hold a Project Closeout review to assess whether the deliverables and KPPs have been demonstrated, and the plan for transitioning to operations and demonstrating the UPPs.

APPENDIX A: iTPC Performance Parameters

This appendix describes the key performance parameters as well as explaining their justification and verification methods. The KPP will be demonstrated during construction and initial testing before installation, whereas the demonstration of UPP needs beam data

Key Performance Parameters

- **dE/dx resolution for pions(muons) for** $|\eta| \leq 0.1$ and $1.0<|\eta| \leq 1.2$ (UPP)
  The resolution of the dE/dx is a critical parameter for the performance of the TPC. The upgraded TPC with the inner sectors will provide part of the total dE/dx signal. For $|\eta| > 1$ the inner sectors are the dominating contributor to the dE/dx and considerable better than the current TPC. This can be measured with beam and be demonstrated after several months of calibration work. Should beam not be available the performance can be demonstrated with cosmic ray running with magnetic field on. The expected performance of dE/dx vs. pseudo-rapidity from a GEANT simulation is shown in the figure.



- **Anode Gain at Nominal Voltage**
  An anode gain of 2000 will be sufficient with the new MPPC design and electronics to ensure a S:N ratio of 20:1 at nominal voltage. This was the performance parameter for the current TPC (Circa 2000) and ensures good cluster resolution and good dE/dx resolution for Particle Identification. The gain on the anode wires can be verified using Fe sources.

- **Tension on the Anode Wires**
  The tension on the anode wires will be measured on all Anode Planes before being joined to the MWPC. The uniformity is required to achieve uniform pad response and good dE/dx resolution.

- **Working sectors or repairable delivered to BNL**
  As chambers are being constructed and tested, all planes will be checked for disconnected and loose wires. It is possible that some wire may break or become loose during transport from SDU to BNL. These will be repaired before installation in the TPC. The key performance parameters are defined such that repairs can be performed on several sectors (but not all) before

installation and still remain within schedule. A working sector is defined as one that provides a signal on more than 98% of the pads , at functioning HV sections, using either a Fe55 source or the Xray tube.

- **Fraction of HV sections operational after installation**
  Each sector has several HV supplies that cover different sections of the anode wire plane. The goal is to have all sector-sections working, but the physics program can be met with some of them not working. A failed section will result in a small loss of phase space. The sectors will be tested with HV at nominal and at +100V.

- **Compatible with STAR DAQ-100**

  The current STAR DAQ1000 system allows reading out events that include the TPC with a dead time of about 5% at 1 kHz and 20% at 2 kHz.
  The iTPC that replaces the current TPC's inner readout should not add significant deadtime to this value and should have similar rate capabilities.
  The threshold values sufficient for the intended physics goals are a deadtime of <8% at 1 kHz and <30% at 2 kHz. This will be demonstrated having a sector fully instrumented and connected to the STAR DAQ system

  The ultimate goal would be the values of the current system which are a deadtime of <5% at 1 kHz and 20% at 1.8 kHz. This will be demonstrated with beam data.

- **Operational electronics fraction**

  There are always electronics channels which are not fully operational for a variety of reasons: broken padplane connectors, bad solder connections on the connectors, failed preamplifier channels, failed ADC channels, failed electronics components, cables, power supplies, trigger cables and other sources of failure. The goal is to have all elements working, but a small number of failures can be tolerated in the installed system. The percentages are for all sources combined: bad padplane connectors, bad FEE channels or FEEs, bad RDO interconnects or RDOs, bad power supplies or various trigger, power & fiber cables.

  We estimate that less than 8% of all the electronics channels can be allowed to fail while we can still reach the intended physics goals.

  We hope to reach the ultimate goal of less than 3% of failed channels at the beginning of a physics run which is comparable to the current TPC electronics. The operational electronics fraction will be verified shortly after installation, and repairs can also be performed at this stage before close-up for physics data.

- **Electronics noise**

  The "noise" is a function of the padplane+SAMPA+FEE which can be determined with electronics mounted on the chambers. The signal is determined by the response of a MIP. The electronics noise in the original electronics was at level of 1.5 ADC counts, which is also the goal for the new electronics. (What is the equivalent e- count?)

- **Electronics gain uniformity**

  A reasonable gain uniformity is needed, but can be calibrated with high precision via a pulser, and can corrected for in clustering/tracking. It can be determined on the bench.

Appendix B: Work Break Down Details

1. Management

Level of effort tasks associated with the daily management, oversight, and assessment of the project. Includes travel supplies for managing the project and QA oversight.

2. Padplane

Includes the effort required for the design, prototyping and fabrication of the pad planes for the inner sectors. It also includes other small PCB boards that are required for the assembly of the strong backs.

3. Mechanics

3.1 Strongback

The strongback is one of the main mechanical elements required for the iTPC upgrade. It is a high precision rigid structural frame for mounting the padplanes and wire grids inside the TPC, and simultaneously for mounting the front end electronics and cooling manifolds on the outside of the TPC. The assembled inner sectors fit precisely on the end-wheel of the TPC with twelve placed on each end of the TPC. The effort is for procurement, qualification of prototypes, fabrication of the full complement of 24 strongbacks + spares, and inspection and survey.

3.2 Tooling for assembly

Drawings & Fabrication for wire mounts

3.3 Strongback and padplane joining

The assembly (gluing) of the pad planes to the strongback is a high precision task that is planned to be carried out by the engineering division at LBNL. The group has the experience, as well as the tools to carry out the task. The padplane as well as the strongback has precision markers embedded. The final sector assembly will be surveyed, and a precision milling of the strongback to ensure the required distance from pad-plane to anode-plane will be performed. An O-ring groove will be milled on the backside of the sector before shipping of completed sectors to Shandong University

3.4 MWPCs

The Multi Wire Proportional Chamber (MWPCs) will be assembled on the strongbacks at Shandong University (SDU). The assembly will be done according to the agreed upon QA plan. The tasks are part of the NSFC key project. The tasks include:

.1 Prototyping

Before mass production of the MWPCs and detector assemblies, a prototype with all final designed parts (strongback, padplane etc.) will be completed and tested after QA.

.2 Wire chambers

The wires for the 24 inner TPC sectors will be wound on wire-transfer frames using a custom winding machine. There will be 72 wire planes in total. The wire tension will be measured for each wire plane and checked for qualification prior to assembly.

.3 Assembly with strong back

Three layers of wire mounts (anode, shield and gated grid) will be mounted and pinned to the strongback. The relative height of each wire mount and wire plane is precisely controlled relative to that of the padplane. The corresponding wire planes will be glued and soldered onto the wire mounts using precision wire combs to guarantee the wire spacing (pitch) and the distance between the wire planes and the padplane.

.4 Testing

The assembled sector will be inspected and tested for performance (gain uniformity, efficiency) with a gas-filled test chamber using the iTPC DAQ system.

.5 Shipping

After the tests are complete and qualified, the sectors will be stored in a hermetically sealed boxes with constant N2 flowing and then shipped to BNL for final test and installation.

The SDU group will report weekly on progress, and QA will be checked regularly by the iTPC project team. A detailed testing plan is being established, and the QA results and specifications will be entered into a set of travelers which will follow each sector as it goes through the various assembly steps.

4. Installation

4.1 Installation of the inner sectors

This task includes removing the old electronics from the TPC sectors, setup of the insertion tooling, and replacement of the 12 inner sectors on each side of the TPC in a clean-room environment.

4.2 Installation of services

This task includes removal (and reinstallation) of all electrical power, gas circulation, water cooling and signal readout system before (after) replacement of the iTPC sectors.

5. Electronics

5.1 SAMPA chips

This task includes the procurement of the SAMPA chips, which are being developed for the ALICE upgrade at LHC. The chips are an essential part of the FEE card upgrade.

5.2 FEE

This task includes prototyping and fabrication of the iRDOs (RDO's for the iTPC). The iFEEs are small printed circuit boards, which connect directly to the pads via the padplane connectors and will house the SAMPA ASICs. The iFEE also contains an FPGA, which is the controller that will set various SAMPA operating parameters during the configuration phase. During the data-taking phase, the FPGA will multiplex the data onto a fast serial link towards the Readout Board (see next section). It will also supply the correct regulated voltages to the SAMPA chips as well as the necessary reference voltages for SAMPA's ADC. The power to the FEE is provided via links from the RDO board.

5.3 RDO

These task includes prototyping and fabrication of the iRDO. The iRDO is an electronics board, which serves a number of purposes within the electronics chain of the iTPC upgrade. It acts as the multiplexer for the SAMPA data coming from the iFEEs onto the STAR-standard fiber links which connect to the DAQ Sector PCs. It also serves as the STAR trigger and clock interface/control to the iFEE and SAMPA. Finally, it provides power regulation and fan-out from the remote power supplies down to the iFEEs and provides the necessary PROMs for the iFEE FPGA remote configuration.

5.4 DAQ

Additional components will be added to the TPC's STAR DAQ system for a twofold increase in data volume from the inner sectors. This includes additional PCs, Fibers, and readout controllers.

5.6 Power Supplies

The TPC power distribution scheme will be updated. Each RDO (and associated FEE cards) is powered by one dedicated dual-voltage power supply (dual for analog and digital subsystems of the electronics) located in the TPC Power Supply Racks on the STAR South Platform.

Appendix C - Risk Management Plan

Introduction

Project risk is a measure of the potential inability to achieve project objectives within defined scope, cost, schedule, and technical constraints. Project risk management entails the systematic process of identifying, quantifying, handling, tracking, and reporting risk events. Risk events are defined as individual occurrences or situations that are determined to have potential negative or positive impacts to a project. Project risk management includes maximizing the probability and consequences of positive events and minimizing the probability and consequences of adverse effects to a project.

The iTPC project team is committed to managing project risk effectively by employing a comprehensive strategy that emphasizes risk identification and prevention or mitigation. The overall objectives of the Risk Management Plan (RMP) are to prevent or minimize unnecessary project costs and/or schedule delays, while achieving the project scope. *This Risk Management Plan (RMP) describes the overall philosophy and process for risk management.*

Risk Assessment for the iTPC Project

The Risk Management Plan takes a broad view of the iTPC project to identify and address specific risks that require assessment, mitigation and tracking. While the initial risk assessment will be focused on the establishment of a valid baseline, risk assessment will also be an ongoing process throughout the project life cycle. In addition, the following assumptions will serve to guide and bound the risk assessment:

- The project will be executed in accordance with RHIC/STAR and Brookhaven National Laboratory Policies and Procedures.
- The project scope will be limited to the scope of the Memorandum of Understanding (MOU) between STAR and the BNL Associate Directors Office.
- The installation, integration, commissioning and operation of the project will be executed in accordance with RHIC/CAD and STAR Policies and Procedures.
- The project will be carried out by the STAR Collaboration and will be dependent on the STAR/RHIC operations schedule.

1. Risk Registry and Strategic Risk Management

Strategic project planning is based on a top-down Risk Analysis that identifies all significant technical, cost and schedule risks, which are tabulated in the formal Risk Registry. For risks not yet retired, mitigation strategies are developed that are taken into account when making decisions about R&D efforts, design and purchasing strategies, production methodologies and schedules, and other significant aspects of project management and execution.

Informal risk analysis and assessment are implicit in the day-to-day operation of the project, as the project management team responds to new vendor quotes, further experience with detector production, and so on. The Project Management Team will in addition carry out more formal reviews of project risks, updating the Risk Registry as needed. Prior to the start of each significant new sub-project, a focused risk assessment will be performed to ensure that significant new risks are identified and the appropriate risk handling measures are incorporated into project planning.

Risk Analysis and Monitoring

Individual risks are tabulated in the project Risk Registry. A single risk owner is assigned to monitor each risk and to develop avoidance or mitigation strategies, with ownership assigned by the Project Management Team.

The Project Manager is responsible for overseeing the development and maintenance of the Risk Registry and for coordinating the risk management process along with the Level 2 Managers. Experience within the project has shown that joint ownership of the Risk Registry by the Level 2's and the Project Manager is advantageous, since a wide range of experience is required to cover all areas of project risk.

Project risks are assessed for likelihood of occurrence and for potential consequences to the project cost and schedule.

Risk monitoring is required throughout the life of the project. The objectives of risk monitoring are to:

- monitor the appropriateness and validity of mitigation strategies
- ensure that risk mitigation measures have been implemented as planned
- evaluate the effectiveness of the risk mitigation measures
- identify previously unanticipated risks
- retire risks

Risk monitoring and assessment will include reviews by the Project Management Team, facilitated jointly by the Project Manager and the Level 2 Subsystem Managers. These reviews may lead to reevaluation of the technical performance of a sub-project, additional or modified risk mitigation measures, scope change requests, reallocation of resources, revised probability/consequence and expected value estimates, adjustment of contingency, or retirement of risks. Work plans and mitigation strategies will be adjusted continuously to take advantage of lessons learned and to maximize the probability for successful project completion.